TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XXI, No. 7. JULY, 1944. PRICE 6d.

CONTENTS

	PAGE
Agricultural Problems of the West Indian Cotton Industry	121
Note on the "French" or "Small-Seeded" Cotton grown in the West Indies in the 18th Century	123
Application of Genetics to Plant Breeding ...	126
Observation on Cacao on the Paria Peninsula, Venezuela	130
Tropical Butter-Fat Spread	132
Storing Sweet Potatoes	132
Hay-Making under Conditions obtaining in the Drier West Indian Islands	133
Soil Structure and Tillage	135
Soil Organic Matter	137
Agricultural Developments in the U.S.S.R. ...	138
Chemical Notes	139

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 0365

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and Subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Grand Buildings, Trafalgar Square, London, W.C. 2, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

AGRICULTURAL PROBLEMS OF THE WEST INDIAN COTTON INDUSTRY *

SEA Island cotton is the most suitable cash crop for considerable areas in the British West Indian islands. Its maintenance on a stable basis in the post-war economy is therefore of very great importance to those concerned with the welfare of the island communities as well as to those interested in assuring a steady supply of the finest cotton.

The future success of the industry depends on three basic factors, (1) the maintenance of the present high standard of uniformity in the product, (2) the control of pests and diseases, and (3) the improvement of yield to give a satisfactory return in the face of increased competition from other fine cottons.

Uniformity in the product has been achieved by very careful attention to breeding and seed supply. At present the whole crop is produced from three varieties, all of which are closely bred and genetically very uniform. The average amounts and proportions of the crop contributed by them over the seasons 1935-36 to 1939-40 are given below :—

Variety	*Islands*	*Lint yield* 1935-36 *to* 1939-40. *Average (lb.)*	*Per cent.*
MSI	Leeward Islands	1,424,012	73.8
V.135	St. Vincent	... 499,344	25.8
BSI	Barbados	... 7,458	0.4
		1,930,814	100.0

The industry is dominated by the production of MSI in the Leeward Islands. Barbados production is of little account, and the Island's breeding work is—and is likely to remain—on a minimum maintenance basis.

The complete collection of Sea Island varieties now maintained in St. Vincent provides a reservoir of variability that will be the basis of any future breeding work. So far as can be seen at present, however, the varietal needs of the industry will be met by the three varieties mentioned above, and the rest of the collection should be carried on as a safeguard in case of long term changes in demand or agricultural requirements that cannot now be foreseen.

* Report by J. B. Hutchinson of the Cotton Research Station, Trinidad, B.W.I., to the Empire Cotton Growing Corporation. Reproduced by permission.

Though some features of pest incidence on Sea Island cotton remain to be elucidated, the main problems of control have been solved. The protection of the crop from serious pest attacks now depends on the efficient carrying out of close season and clean-up regulations and prevention of the re-establishment of alternative stainer hosts, and on prompt and thorough destruction of fresh invasions of cotton worm.

In the past the greater part of the technical assistance given to the Sea Island industry has been devoted to the improvement of the varietal situation and to pest control, and it is in consequence of the success of this work that seed supply and pest control are now largely routine matters. Yield improvement by cultural methods has not received the same attention, but enough has been done to show on the one hand the crying need for better farming systems, and on the other, the great opportunities that exist for agricultural betterment.

The problem created by the pressure of the expanding population on limited land resources has been emphasised by all who have studied the social conditions of the West Indies. The possibilities of relief offered by more intensive agriculture may be illustrated by the disparity in cotton yields between estate and peasant holdings in St. Vincent. Manning (1943) reported that in 1942-43 the mean yield of lint from all estate cultivations was 142 lbs. per acre, and from all peasant cultivations, 62 lbs. per acre. When it is considered that yields of 400 lbs. per acre are by no means uncommon, the scope for improvement by better farming methods can be visualised.

The exploitation of the possibilities of improved yields by better farming depends on the extension of present knowledge of West Indian soil types, their rehabilitation where they have been eroded, their conservation and amelioration by suitable cultivation methods, and their improvement with organic and mineral manures. The soil sequences in the cotton-growing islands have been outlined by Professor Hardy, with the help of agricultural officers in the islands, and some information is available on the mineral nutrient status of the main types. Soil conservation work has made a good start, but has not yet been linked up very closely with studies of soil type and the information available on nutrient status.

The Sea Island crop is timed to mature in two different seasons. In most islands it is planted in August or September and ripens in the dry weather from January to April. The plant develops in an environment which is steadily becoming drier, and the sequence of vegetative and reproductive growth is normal. In general the cropping seems to be dominated by the nitrogen supply, and the major manurial problem is the maintenance of the optimum nitrogen level. In Montserrat and St. Kitts the crop is sown whenever suitable rains occur in the comparatively dry months of March and April. The plant develops in an environment that gets progressively wetter, and the normal sequence of vegetative and reproductive growth is apt to be seriously upset, especially on the shoal soils with impeded drainage that comprise a large part of the cotton lands of Montserrat. Unless the fruiting phase is well established before the onset of heavy rains, the plant "runs to bush", "black boll" takes much of the crop that sets, extensive shedding occurs, and in extreme cases physiological diseases (chibble leaf, loggerhead) set in and lead to complete sterility of the upper branches. These physiological disturbances are often more severe on lands with a high nitrogen status, and under such conditions nitrogen manuring may be no more than a gamble on the weather.

It is noteworthy that on the shoal soils of Nevis, with September planting, these physiological disturbances have not been reported. Though the obvious solution of the physiological problem would appear to be to change the planting season to September, there is no denying that, given a favourable weather sequence, Montserrat produces heavy crops, in spite of its large area of comparatively intractable shoal soil. Montserrat and St. Kitts, over a 23-year period ending 1941-42, averaged 184 and 191 lbs. of lint per acre respectively, against 123 lbs. per acre for Antigua, 111 lbs. per acre for Nevis, and 117 lbs. per acre for St. Vincent. (Data from *7th Report, W. I. S. I. C. A.*, 1942). Evidently an understanding of the underlying factors governing the fruiting of Sea Island cotton might lead to a very large increase in crop yield.

Besides Sea Island cotton, the West Indies also produce about 1,000 bales of perennial cotton in the Grenadines. This Marie Galante cotton might be a valuable asset if the industry were properly controlled. The establishment of a central ginnery has been agreed on, and co-operative ginning and marketing are the first essentials if a good, clean, even running cotton is to be turned out. Replacement of the existing mixture of types can only be gradual with a perennia crop. Improvement is being sought by the compulsory eradication of the coarse *G. barbadense* component of the crop. A superior Marie Galante strain (AHV) is available, and only AHV seed is issued to supply the gaps caused by natural mortality and by the uprooting of *G. barbadense* plants.

The basic problem of the Grenadines is soil erosion. In Carriacou, Evelyn (1935) recorded over 5000 acres under cotton cultivation in 1935. In 1943 the acreage surveyed for the eradication of *G. barbadense* amounted to little more than 3000. The reduction may be ascribed entirely to erosion, and though the figures are only approximate, they give an idea of the appalling rate at which the cultivable area is shrinking. The deterioration has persisted over a much longer period. In 1787 it was recorded (Edwards, cited Stephens 1944) that "in seasonable years" Carriacou produced 1,000,000 lbs. of lint. In the

last 25 years production has never exceeded 425,000 lbs., and has only three times exceeded 375,000 lbs.

As with other West Indian islands, soil conservation can only be achieved by the adoption of a better farming system. The essentials of such a system are improved cotton cultivation, with regular replanting, a food crop rotation, and stock keeping.

References

Evelyn, S. H., 1935 Report on a Visit to Carriacou. (*Unpublished.*)

Manning, H. L., 1943 Progress Reports from Experiment Stations. *E.C.G.C.*

Stephens, S. G., 1944 *Trop. Agriculture, Trin.*, 29, 23-9.

NOTE ON THE "FRENCH" OR "SMALL-SEEDED" COTTON GROWN IN THE WEST INDIES IN THE 18th CENTURY

BY

J. B. HUTCHINSON AND S. G. STEPHENS
(*Empire Cotton Growing Corporation, Cotton Research Station, Trinidad, B.W.I.*)

I. Introduction

Surveys (Hutchinson, 1943 a & b and in press) of the indigenous perennial cottons found in the West Indies to-day have shown that they are confined to two varieties of each of two species of *Gossypium*; (1) *G. hirsutum* var. *punctatum*, (2) *G. hirsutum* var. *marie-galante*, (3) *G. barbadense* (free-seeded type) (4) *G. barbadense* var. *brasiliense* (kidney-seeded type). Of these (1) is not found in the Lesser Antilles but has been reported in the Bahamas, Puerto Rico, Haiti and Cuba, and is apparently only present as a recent introduction in Jamaica. In the Lesser Antilles (2) is easily the most commonly occurring type, particularly in the drier areas, but (3) and (4) are also found growing under more mesophytic conditions.

The chief interest of these cottons and their distribution lies in the high probability that the majority of them are relics of the perennial cotton crops which formed, at the close of the 18th century, one of the most important exports of the West Indies to European markets. If the present relative frequencies of the four types furnish a true picture of their former status it is to be expected that *G. hirsutum* var. *marie-galante* was the major constituent of the 18th century crops. In order to test this a search was made (Stephens, 1944) through old records in the collection of the Trinidad and Tobago Historical Society. The result was only partially successful since the old botanical descriptions were not accurate enough to enable all the types to be classified with confidence. However, with the exception of the kidney-seeded habit all the characters described are well within the range of the *marie-galante* types found in the West Indies to-day.

The most comprehensive classification of cottons grown in the West Indies in the 18th century is that of Edwards (1793). He divides them arbitrarily on the basis of seed characters into two main groups (1) Green-seeded in which the de-linted seed has a downy covering of fuzz hairs and (2) Shrub cottons (black-seeded types) in which the de-linted seeds are naked except for a tuft of brown or whitish hairs (sometimes absent) around the beak of the seed. Recent investigations leave little doubt that the Green-seeded type was an agricultural race *i.e.* "agrotype" (Gregor, 1933) of *marie-galante*. Borde (1876) describes the cottons cultivated in Trinidad in the mid-19th century as being "tree-like and of the green-seeded variety with long and fine lint, cultivated principally on the different estates around the Gulf and in the Bocas". Since to-day the cotton population of this area consists almost exclusively of *marie-galante* types which all have green or greenish brown fuzzy seeds, there can be no question of the identity of the formerly cultivated types. The identification of the Shrub cottons is more difficult. Edwards sub-divided them into Common Jamaica, Brown Bearded, French or Small-seeded, and Kidney or Chain cotton. Evidence has already been advanced (Stephens, 1944) which leads to the conclusion that the Common Jamaica and the Kidney cottons belonged to *G. barbadense* and its variety *brasiliense* respectively, while the Brown Bearded was almost certainly a *marie-galante* type. Edwards described the French or Small-seeded type as being the cotton cultivated in Hispaniola and later introduced into the British Islands. It had small seeds with a whitish tuft and lint of greatly superior quality, but was less hardy than the other cottons grown. *Marie-galante* cottons as a whole have much smaller seeds than *barbadense* and the question at once arises as to whether the French cotton was merely a fine linted selection of *marie-galante*. The *barbadense* perennial cottons in the West Indies to-day are certainly coarse linted in comparison with the *marie-galante* types. On the other hand it is difficult to rule out *barbadense* entirely without independent evidence particularly since there was an old but unconfirmed belief that the ancestors of the present high quality annual Sea Island cottons (*G. barbadense*) were introduced into the Southern States from the West Indies. An obvious source of independent evidence worth investigation was to sample the

perennial cotton population of those islands which were under French Government when cotton growing in the West Indies had reached its maximum development, and which also had a reputation for good quality cotton. From this point of view two West Indian islands are of great interest (1) Hispaniola (Haiti and San Domingo) (2) Tobago.

According to Edwards the cotton of Hispaniola in 1780 had a finer staple than that of other cottons grown and he also states that it was the "French" type which was cultivated. At that time the western part of the island (Haiti) was one of the most valuable French possessions owing to its great agricultural fertility, and it is likely that cottons grown successfully there would have been introduced into the other French, or formerly French islands, particularly those in which cotton was an important crop (*e.g.* Grenadines and Virgin Islands). The cotton grown in Tobago in 1780 when it was a British possession was of inferior quality (Edwards, 1793) but in the following year the island fell into the hands of the French and remained under their control until 1793. This period of French ownership happened to coincide with the boom in cotton growing which followed the development of spinning machinery in Europe and the destruction of cane plantations in the West Indies by the sugar ant. As a consequence cotton became the premier crop of the island under French rule and in the year 1792 "the finest cotton ever brought to the English market" was grown on the Robley estate (Golden Grove) in Tobago. The most likely explanation of this remarkable improvement in quality during the short period of French ownership is that a superior strain of cotton had been introduced by the French, since it is known that lint characters are comparatively little affected by changes in soil fertility such as would have accompanied a general improvement in agricultural practice. Thanks to collections made in Tobago recently by Miss M. Smith, formerly Assistant at this Station, and by Messrs. D. Laycock and J. Todd of the Imperial College of Tropical Agriculture, it is now possible to demonstrate that a superior strain of *marie-galante* cotton whose characters agree with Edwards' description of "French or Small-seeded" cotton is still in existence in the island. Unfortunately no collections have so far been obtained from Haiti, although certain conclusions can be drawn from the published descriptions which are available.

II Tobago

According to Thornton (1908) the island of Tobago may be divided fairly sharply into a south-westerly potential cotton-growing area and a north-easterly cocoa area—the division being a line drawn from Plymouth on the north coast to Scarborough on the south coast. In the drier and more open country to the south west of this line it is certainly true that cotton trees are common while in the more shaded and moister area to the north-east they occur but rarely. This distribution agrees with Hutchinson's previous conclusion from cotton surveys in Jamaica, Trinidad, and Puerto Rico, that without cultivation perennial cottons only survive in areas which are kept clear of surrounding bush; either artificially by brushing and clearing in the neighbourhood of homesteads and growing crops, or naturally by ecological conditions which favour the maintenance of an open plant community. Dry areas near the sea coast and in the neighbourhood of villages represent highly favourable conditions for their survival.

The samples of cotton obtained in the present survey were all found in the neighbourhood of homes or cultivated fields *i.e.* none were truly wild types. In this particular therefore the situation is similar to that obtaining in Trinidad and different from that in Jamaica where colonies of wild cottons are found. Botanically, however, Tobago cottons differ from those in Trinidad in two particulars. In the first place only one variety, *G. hirsutum* var. *marie-galante*, was found in a survey comprising 41 cotton trees the majority of which were growing in the south-westerly area. In Trinidad, although *marie-galante* is by far the most common type, both free and kidney-seeded *barbadense* cottons would be expected to occur in an equally extensive survey. Secondly, in Tobago both green-seeded types, and black-seeded types with brown or brownish white tufts occur, whereas only fuzzy types (green or greenish-brown seeds) have been found in Trinidad. Superficially at least, the fuzzy-seeded *marie-galante* types are indistinguishable from those found in Trinidad, while the tufted types resemble rather less closely the tufted types found in the Grenadines and Virgin Islands. These latter types have clean black seeds bearing tufts which have a pronounced rusty colour, while the Tobago types have tufts varying from rust coloured to a dull brownish-white and the seed surface frequently bears thinly scattered hairs of the same colour (semi-fuzzy types).

If the tufted seeded Tobago cottons are really the relics of Edwards' French or small-seeded type, introduced in the 18th century by the French as has been suggested, they should have a superior lint to the earlier established green-seeded type (*i.e.* assuming that the original type cultivated was green-seeded as in Trinidad). Accordingly lint lengths were measured from all the Tobago samples and compared both with Trinidad samples and with data reported by Evelyn (1931) from a pure *marie-galante** selection taken from the mixed *marie-galante* and *barbadense* crop grown in the Grenadines. The results are presented in the Table and lead to the interesting conclusion that the fuzzy-seeded Trinidad and Tobago cottons do not differ significantly in length; neither is

* It should be noted that there has been some local confusion in the nomenclature of Grenadine cottons. "Marie-galante" has been used wrongly in Evelyn's paper to indicate the *barbadense* component of the crop, while the term "Silk Cotton" denotes the true *marie-galante*.

Table

A comparison of lint length in four collections of West Indian *marie galante* cottons. In the first three collections each entry represents a different tree and usually a different district.

(Lint length mm.)

Collection	20	22	24	26	28	30	32	34	36	38	40	42	44	Total
Tobago (fuzzy seeds)	—	—	2	2	8	5	5	4	1	1	—	1	—	29
Tobago (tufted seeds)	—	—	—	—	—	—	1	2	4	1	2	1	1	12
Trinidad (fuzzy seeds)	—	—	1	1	4	1	3	3	—	1	1	—	—	15
Grenadines (tufted seeds)	—	—	—	—	—	—	—	1	1	3	2	2	1	10

Mean lint length (mm.)

tufted	Grenadines	39.2 ± 0.95	insig.	signif.
	Tobago	37.3 ± 1.03		
fuzzy	Trinidad	31.2 ± 1.13	insig.	
	Tobago	30.6 ± 0.75		

there any significant difference between the Grenadines sample and tufted Tobago types. There is however a highly significant difference between fuzzy and tufted-seeded types, the latter having a considerably longer staple. Now although fuzzy seeds are known to have a denser cover of lint than tufted seeds, there is no evidence of any association of the tufted seed habit with lint length and fineness. It is in fact known from the results of Shirley Institute hair tests that a Sea Island fuzzy-seeded type arising as a mutant from the normal (tufted-seeded) type has a similar lint length. The most likely interpretation is therefore consistent with the historical evidence *viz.* that there are two agrotypes of *marie-galante* in Tobago to-day which correspond to Edwards' "French" and "Green-seeded" cottons of the 18th century.

III Haiti

According to Cook (1923) the native cultivated cotton of Haiti "undoubtedly belongs to the species that is known botanically as *Gossypium purpurascens*". There has in recent years been much confusion in the use of this name. Hutchinson (in press) has shown that it was originally applied to types of *G. hirsutum* var. *punctatum* from Puerto Rico but it is now more often used for var. *marie-galante* to which variety it is evident from Cook's botanical description and photograph that the Haitian cotton belongs. More generally Cook describes the cotton as "a large perennial bushy plant, often growing to a height of eight or ten feet" and "generally distributed about the towns as well as in the rural districts of Haiti, either as a door-yard plant or growing half wild in neglected grounds or waste places". It has "small slightly fuzzy seeds" with "staple from an inch to an inch and a quarter". Reference to annual reports in the Haitian "Service technique du Departement de l'agriculture" shows that subsequently selection was carried out on the native crop, particularly for lint length and yield. As a result a considerable improvement was obtained and in 1934-5 (see Annual Report for that year, p.33) types with lint length of 39.6 mm. had been obtained.

It is clear from these brief records that the distribution of the plant is quite in accordance with its distribution in other islands, and also that by straightforward selection in the general crop population, high quality strains can be isolated which equal in lint length the high quality type found in the Grenadines and Tobago (*c.f.* with appropriate figures in Table). The "slightly fuzzy seeds" as far as may be judged from Cook's description resemble the semi-fuzzy types found in Tobago. There is good reason to believe that semi-fuzzies are extreme variants of true tufteds and distinct from fuzzy types, this conclusion being based on the results of unpublished breeding experiments carried out at this Station with fuzzy × tufted crosses. Subject to confirmation by examination of samples of Haitian cotton, the conclusion therefore seems justified that the "non-fuzzy" *marie-galante* cottons of Haiti, the Grenadines, the Virgin Islands and Tobago represent the relics of the French or Small-seeded cotton which was so esteemed in the 18th century.

References

Borde P. G. L. (1876) "Histoire de l'Ile de la Trinidad".

Cook O. F. (1923) *J. Hered.*, 14, 323-35.

Edwards B. (1793) "History of the West Indies". Vol. II.

Evelyn S. H. (1931) "Report on a visit to Carriacou" Grenada. *Council Paper* No. 19.

Gregor J. W. (1933) *Ann. Appl. Biol.*, 20, 205-19.

Hutchinson J. B. (1943a) *Trop. Agric., Trin.*, 20 56-8.

Hutchinson J. B. (1943b) *Trop. Agric., Trin.*, 20, 253-8.

Hutchinson J. B. (in press) *Puerto Rico Agricultural Journal.*

Stephens S. G. (1944) *Trop. Agric., Trin.*, 29, 23-9.

Thornton T. (1908) "Tobago as a field for cotton cultivation" Trinidad, Govt. Print.

THE APPLICATION OF GENETICS TO PLANT BREEDING

BY

S. G. STEPHENS

(*Empire Cotton Growing Corporation, Cotton Research Station, Trinidad, B.W.I.*)

In considering the application of genetics to plant breeding methods it must be remembered that the art of crop improvement originated in pre-historic times—probably soon after the human race passed from the nomadic food gathering phase into a stage of settled communities. The birth of genetics as a science, therefore, in 1900 found all the chief agricultural crops already highly improved as a result of thousands of years of conscious or unconscious selection by man. To-day when one compares a cultivated crop with its nearest wild relatives, it is difficult to believe that post-Mendelian improvement will be in any way commensurate with the advances which have gone before. In certain crops, special characters can be recognised whose incorporation has obviously been of primary importance to successful cultivation, and in all cases these characters must be of extremely ancient origin. The non-shattering rachis of wheat, the non-articulate grain base in oats, the peculiar type of inflorescence found in cultivated maize, the convoluted (and hence spinnable) hairs of cultivated cottons, the parthenocarpic (and hence edible) fruit of the banana may all be cited as characters of ancient origin and of major importance to man, which are present in the cultivated species but absent from their nearest wild relatives. However the fact that, from the present-day perspective at any rate, the most significant improvements on the wild ancestor have already been achieved need not engender a pessimistic outlook for the future. What *is* important is the realization that further improvement, in the absence of novel mutations of practical importance, demands the fullest use of existing scientific methods and the invention of new ones if it is to be worthwhile.

Genetics in its early days was confined to factorial interpretations of the simpler types of breeding behaviour *e.g.* the inheritance of flower and seed colours. The subsequent recognition that most characters of agricultural importance have a much more complex nature, has meant that until recently genetics has made little direct contribution to plant-breeding technique. In other directions however genetics has advanced rapidly. It may perhaps be argued that its advance has been greatest when its general principles have been incorporated with specialized knowledge of other scientific disciplines (1) with cytology and taxonomy in order to throw light on the mechanism of speciation (2) with statistics to open up new fields in studies of human inheritance and in examining possible methods of evolution as a whole and (3) with physiology and embryologyto gain an understanding of growth and development. It is the object of this paper to summarise, from the economic point of view, the most important aspects of these three lines of development and to show that they are of significance to the plant breeder.

(1) Taxonomic Genetics and Cytogenetics

It is clear that when a crop is propagated by seed, is very variable, and has not undergone stringent selection, detailed genetic and cytological investigation is not at the outset necessary: improvement is a straight problem in selection such as was employed successfully in pre-Mendelian days by such breeders as le Couteur, Hallett, and presumably many anonymous crop improvers of much earlier times. Selection as the sole method of improvement has now been practically exhausted in temperate crops of economic importance, though it is still the chief method employed with many tropical crops. Even here, however, selection alone must sooner or later prove inadequate and combination of characters from different sources will become the essential step for further improvement. As an example of this stage in breeding let us consider a crop which consists of relatively pure and easily recognisable strains—a condition achieved by close inbreeding and selection as in cereals (Hunter and Leake, 1933) and in cotton (Hutchinson and Manning, 1943). Since genetic (*i.e.* heritable) variability is approaching a minimum, hybridization has to be adopted in order to provide fresh variability from which the plant breeder can select. At this stage the plant breeder must have a certain minimum equipment if he is to work efficiently. His first and most obvious requirement is a thorough knowledge of his crop from the agronomic point of view and a clear idea of the improvement he desires to effect. This is complicated by the fact that the improvement desired fluctuates with changes in the economics of crop production and in the demands of the consumer. Since worth-while breeding programmes are usually long term projects, several must be run concurrently to keep pace with changing requirements. Secondly, he needs some idea of the wealth of material at his disposal in his search for possible parents of future improved lines *i.e.* he must be equipped taxonomically. Thirdly, he must realize the limitations of any crossing programme which he has in mind, and this demands at least a working knowledge of the cytological relations within the taxonomic group with which he is working and preferably some idea of what Harland has termed its "genetic architecture".

The importance of taxonomic knowledge to the plant breeder is not confined to recognising species and higher units of classification from orthodox morphological descriptions in a standard Flora. The agricultural "varieties" with which the breeder works represent much finer shades of differentiation than these. In recent years, however, an important branch of taxonomic genetics has been developed (Turesson, 1922; Clausen et al, 1940; Gregor, 1933, 1938) which consists of

quantitative studies of plant characters, as they occur in natural populations, in relation to differences in ecological habitat. As a result of such studies, definite ecological races (ecotypes) can be recognised, in each of which a characteristic *average* genetic composition has been developed under the influence of natural selection. Gregor (1933) has pointed out the importance of classifying agricultural "varieties" of crop plants on a similar basis, in order to give the plant breeder information of what types (or their hybrids) are likely to prove valuable under definite localised conditions.

Within the limits of a single inter-fertile group of plants the breeder has to contend with problems which demand an appreciation of genetic architecture. In selecting parents, types are chosen both of which possess desirable characters, and the object in view is to combine all these desirable characters in one type. Sooner or later, in any crop which has undergone considerable improvement, further advance along these lines becomes restricted since all the more obvious advantageous combinations have been secured. "Transgressive" breeding may then be adopted. This method depends on the fact that most characters of economic importance depend on the action of many genes and hence any single economic character, *e.g.* earliness of ripening, resistance to disease, may be built up in several alternative ways. Thus indicating "desirable" genes by capitals and "undesirable" or "inferior" genes by small type, it may be that two parent plants *ABCD efgh* and *abcd EFGH* have equal economic values, built up in two different ways. It is theoretically possible by crossing and re-selection to isolate types which "transgress" the parental values *viz. ABCDEFGH*, superior to both parents, and *abcdefgh*, inferior to them. A practical example is provided by the breeding of shortness of straw in the "Resistance" oat (see Hunter and Leake, 1933). If genes acted independently however, as is implied by this symbolization, the greatest scope in transgressive breeding would be provided by crosses between parents which differed so much in their genetic complements that all their desirable characters were built up in different ways. The plant breeder would then select parents from distinct but interfertile species, thus maximising gene differences within the limits of the breeding material. Actually all exhaustive genetic analyses lead to the conclusion that genes do not act independently and Harland's work on speciation in *Gossypium* (summarised Harland 1934) has shown conclusively that each species is built on its own characteristic and co-ordinated genetic plan. Crossing between species therefore disrupts the co-ordination, and a medley of unbalanced types segregates out in F_2 and later generations. The chances of synthesizing superior types by interspecific crossing and selfing in *Gossypium* appear to be rather less than the chances of constructing a superior type of motor-car from a random selection of parts taken from two distinct "parental" models. But, carrying the analogy a little farther, the chances of manufacturing a superior type are greatly improved if one brand of car is selected as a basis for improvement, and minor accessories from another brand are substituted (in so far as the general lay-out of the basic model permits). This in fact forms the genetic basis for the "backcross technique" employed by Richey (1927) and Briggs (1935) in cereal breeding, by Harland in genetic analyses of *Gossypium*, and recently by Knight (unpublished) as a means of transferring Blackarm resistance from Upland (*G. hirsutum*) to Egyptian (*G. barbadense*) cottons. In this method one species is chosen as the imperfect model of a desirable type and improving characters controlled by relatively few genes are introduced by repeated backcrossing. Backcrossing ensures that the new characters are introduced without losing the good qualities already present in the "model" (*i.e.* the recurrent parent) and thus has considerable advantages even when both parents belong to the same species (Briggs, 1935).

The fact that most breeding programmes to-day in sexually propagated crops are confined to inter-fertile groups and usually to single species, does not necessarily mean that future projects will be so restricted. For example, in cotton, the cytological analyses of Webber and Skovsted have shown that the cultivated Asiatic, and the cultivated New World cottons belong to two distinct groups of species which have different chromosome numbers, and have worked out their relationships with other non-cultivated species of the genus *Gossypium*. Making use of this knowledge Harland (1940) and Beasley (1940) have demonstrated the possibility of synthesizing new species by colchicine treatment of sterile hybrids (induced amphidiploidy) and the potential bearing of such syntheses on future cotton breeding practice has been outlined by the writer (Stephens 1942). This, however, is long range work of exploratory rather than proven value. From the *immediate* economic point of view it is a waste of time to consider crossing programmes involving different chromosome sets (genoms) until it is certain that the genetic variability within each set is not sufficient to supply the plant breeder's requirements as raw material for selection.

So far, attention has been confined to the case of a sexually propagated crop, and it will have been noted that although the cytological situation sets important limits to the plant breeder's activities, yet on the whole it plays a rather passive rôle. This is far from being the case when vegetatively propagated crops are under consideration. Recent work on the banana carried out at the Imperial College of Tropical Agriculture (Dodds, 1943 and in press) emphasizes how no logical breeding programme is possible without a thorough knowledge of *Musa* cytology, and an ability to forecast the probable results of certain crosses from an intensive study of the complex irregularities which occur in female gamete formation. On the other hand, the potentialities of genetic recombination are

less likely to play an important part in banana breeding, since the desirable type once obtained can be immediately fixed by clonal propagation.

(2) Statistical Genetics

This branch of applied genetics probably represents one of the most important contributions to improvement in plant breeding technique as long as it is not used as a superficially quick method of getting results at the price of neglecting more tedious but fundamentally necessary physiological research. Before the general application of statistical methods, plant selection (particularly for yield) was extremely inefficient since in the early stages of a breeding programme there were no means of estimating how far an apparently superior type of plant owed its superiority to nature or to nurture. If its superiority was not repeated in any of its progeny, the progeny would be discarded but that necessarily entailed raising a large number of progenies in each generation, the large majority of which was discarded each season. It was a wasteful and time consuming system and when applied to the progenies of already highly improved parents it may be questioned whether it was more efficient than random selection. Many progenies must have reached the multiplication stage only to be discarded on their performances under small field scale trials. Later, the application of Fisher's statistical methods and Yates' improved plot arrangements made possible the accurate comparison of quite small progenies, culminating in cotton breeding in the replicated "progeny row technique" of Hutchinson and co-workers in India and the West Indies. The replicated progeny row technique represents a considerable advance in plant breeding method, since it not only transfers emphasis of selection from the single plant to the mean performance of its progeny, but recognises maintenance of variability as being only slightly less important than mean yield. Furthermore, if used effectively, it enables the plant breeder to recognise the scope and limitations of his material. He is able to distinguish between real and apparent progress in the achievement of his object and decide when he has exhausted the possibilities of further improvement (Hutchinson and Manning, 1943).

The replicated progeny row technique clearly offers considerable scope to the plant breeder for some time to come, but with the knowledge at present available it is difficult to see how refinements in technique along similar lines can be carried much farther. Selection is at its greatest efficiency when the ratio genetic/environmental variance is at a maximum (Hutchinson and Manning 1943). Although the replicated progeny row technique maintains genetic variance it cannot be expected to effect any further considerable decrease in environmental variance. Improved plot arrangements only offer hope of minor improvements. Again, however efficiently characters may be compared in any particular experiment, considerable opportunities are lost if the conclusions drawn can provide little general information for workers in other areas or with other crops. The combination of variety trials with manurial experiments &c. widens the scope immensely but renders the subsequent statistical analysis both complex and time consuming. There are therefore practical limitations to expansion along these lines. Moreover, environmental variance reaches its greatest expression in dealing with those characters about which information is most greatly needed. A major problem of selection, therefore, is to devise if possible indices of yielding capacity which are more dependent on the nature of the genotype than on the action of the environment. In fact what is required is some method of estimating potential, rather than actual yield and this will probably require the application of developmental and physiological methods. As Engledow (1939) has said "It is therefore imperative to put new life into field experiments, to interpret them physiologically".

(3) Developmental Genetics

In recent years a new trend in genetics has been occupying increasing attention which offers a hope of closer collaboration between geneticist, embryologist and physiologist. It is therefore of interest to the plant breeder although as yet it has little to offer other than a new outlook. It may be termed a "phenogenetic trend" and is concerned not so much with genes as hereditary units as with genes as controllers of processes within the growing and developing organism. It constitutes a dynamic approach to the problem of genetic control and the most usual line of attack has been to compare (1) the development of the same organ or character in related species or (2) the development of types which differ only in a single gene *i.e.* multiple allelomorphs. Clearly, these methods are as yet in their infancy and for full exploitation a greatly increased knowledge of embryological principles and technique will be necessary. It is probably for this reason that it has progressed more rapidly in the hands of animal geneticists (Goldschmidt, 1938; Beadle and Ephrussi, 1937; Waddington, 1941)—the embryology of animals being more clearly understood than that of plants. Yet, paradoxically, it is in plants that genetic action is seen in one of its simplest forms *i.e.* in the control of shapes or simple patterns (Sinnott, 1937; Hammond, 1941; Stephens, in press (a)). Here it is seen that a single gene can control the relative growth rates of tissues in two or more directions, and that the differential growth rates which occur obey simple mathematical laws (Huxley, 1932). The limited data so far available suggest that the *nature* of such a genetic process is comparatively little modified by the environment or by the action of other genes. Alterations in *timing* of the process may however bring about considerable changes in phenotypic expression, and frequently these changes are not of a random nature but follow well-defined trends (Stephens, in press (b)).

In what way may a phenogenetic outlook be applied with advantage to practical plant breeding problems? It may be argued that in spite of the pioneer work of physiologists on plant hormones (see Went and Thimann 1937) too little is yet known of the physiology of plant development to enable anything more than a superficial idea of gene action to be of practical value in this respect. Even so, in the writer's opinion, these superficial beginnings represent a starting point for new plant breeding methods. At present the plant breeder has few economic characters which he can relate to the known genetic framework. Yield characters in particular require to be translated into terms of growth and developmental processes as a necessary preliminary to determining whether in any of these processes a more simplified form of genetic control can be traced. It is possible, for instance, that genetic control of relative growth rates may not be confined to single plant organs, *i.e.* to leaves and fruits, but that on a larger scale, the growth of the whole plant may similarly be partitioned according to relatively simple laws. Although very little is known about the physiological aspects of flowering and fruiting it may perhaps be accepted that all plants preserve a characteristic balance between vegetative and reproductive growth. A phase of vegetative growth is succeeded by the reproductive phase, the cycle being repeated more or less indefinitely in perennial plants. The relative duration of the two phases may be altered considerably by the environment *e.g.* by changes in C/N ratio in the plant, and by photoperiodic control. In cotton Mason (1922) showed that there was competition between flower initials and apical meristems—the plant could only reproduce at the expense of its vegetative energy, and for any fixed conditions could subsequently only nourish a certain number of developing fruits at a time. This agrees with less comprehensive work in cereals (Hudson, 1934; Stephens 1941) where prolific tillering was found to be to some extent alternative to high yield per year. These facts suggest that if varieties show constant differences in their vegetative/reproductive ratios and if these ratios can be expressed in terms of relative growth rates, useful indices of potential yield will be available. Again in highly improved varieties there is frequently evidence of a "yield ceiling" *i.e.* above a certain limit, number and size of fruits become negatively correlated characters. At this stage the plant breeder must choose whether it is more advantageous to have the same potential yield expressed in many small or relatively few large fruits. His choice will be governed to a large extent by the level of fertility for which he is breeding (Hutchinson, 1943). It is clear that an estimate of the relative contribution of fruit size and fruit number to final yield will be a much more valuable index for breeding purposes than absolute values of these characters, particularly if it can be expressed in simple mathematical terms.

The need for "yield indices" of the type outlined above has been stressed by Engledow (1939) and may be quoted with advantage here since it indicates the rôle which developmental genetics may play in future improvements of plant breeding technique:—

> "Commercial plant characters like yield and quality..... are integrations of the results of many vital processes, the processes themselves being controlled, it is safe to say each by many Mendelian factors or genes. Optimistic talk about the inheritance of such a thing as "yielding capacity" fails to understand that, with existing knowledge, a lifetime of work would not resolve the problem. Yet, to make breeding scientific, these obscure commercial characters must be analysed..... Empirical small scale tests and observation of "associated characters" have proved helpful in this matter. A great development of them is one of the outstanding needs of plant breeding."

In preparing this paper the writer has been greatly indebted to Dr. K. S. Dodds for valuable criticism.

References

Beadle G. W. and Ephrussi B. (1937) *Genetics* 22, 76.
Beasley J. O. (1940) *Amer. Nat.* 74, 285.
Briggs F. N. (1935) *J. Amer. Soc. Agron.* 27, 971.
Clausen J., Keck D. D. and Hiesey W. M. (1940) "Experimental studies on the nature of species *Carnegie Inst. Wash. Publ.* No. 520.
Dodds K. S. (1943) *Emp. J. Expt. Agric.* 11, 89.
Dodds K. S, "Genetical and cytological studies in *Musa.* VI The development of female cells of certain edible diploids." *J. Genet.* (in press).
Engledow F. L. (1939) *Emp. J. Expt. Agric.*, 7, 145.
Goldschmidt R. (1938) "Physiological genetics" New York, McGraw Hill.
Gregor J. W. (1933) *Ann. Appl. Biol.* 20, 205.
Gregor J. W. (1938) *New Phytol.* 37, 15.
Hammond D. (1941) *Amer. J. Bot.* 28, 124.
Harland S. C. (1934) *Trop. Agriculture, Trin.*, 11, 51.
Harland S. C. (1940) *Trop. Agriculture, Trin.*, 17, 53.
Hudson P. S. (1934) *Z. Zucht.* (A). 19, 70.
Hunter H. and Leake H. M. (1933) "Recent advances in agricultural plant breeding" London, Churchill.
Hutchinson J. B. (1943) Emp. Cotton Growing Corporation. *Progress Reports*, 1941-2, 168.
Hutchinson J. B. and Manning H. L. (1943) *Emp. J. Expt. Agric.*, 11.
Huxley J. S. (1932) "Problems of relative growth" London, Methuen.
Mason T. G. (1922) *Ann. Bot. Lond.* 36, 457.
Richey F. D. (1927) *Amer. Nat.* 41, 430.
Sinnott E. W. (1937) *Amer. Nat.* 71, 113.
Stephens S. G. (1941) *J. Agric. Sci.* 32, 217.
Stephens S. G. (1942) *J. Genet.*, 44, 272.
Stephens S. G. "The genetic organization of leaf shape development in *Gossypium*", *J. Genet.*, (in press (a)).
Stephens S. G. "The modifier concept" *J. Genet.*, (in press (b)).
Turesson G. (1922) *Hereditas*, 3, 211.
Waddington C. H. (1941) "Organizers and genes" Cambridge University Press.
Went. F. W. and Thimann K. V. (1937) "Phytohormones" New York, Macmillan.

OBSERVATIONS ON CACAO ON THE PARIA PENINSULA, VENEZUELA

BY

A. F. POSNETTE
(*Botanist, Department of Agriculture, Gold Coast*)

AND

MANUEL PALMA,
(*Cacao Agronomist, Ministry of Agriculture, Venezuela*)

IN March and April, 1944, ten days were spent studying cacao on the Paria peninsula of Venezuela (Sucre State). A range of mountains runs along the north coast of the Peninsula; most of the cacao is grown on the plain between Guiria and Yaguaraparo facing the Gulf of Paria, and the rest in the valleys of the mountain range and on the north coast. In 1922 Permuy* estimated the production at Yaguaraparo 2,000 tons, Irapa 1,000 tons and Guiria 500 tons. No rainfall figures are available but the vegetation suggests that rainfall increases from Guiria to Yaguaraparo. Although the visit was towards the end of the dry season, no sign of any drought effect on the cacao, was seen except between Carupano and El Pilar which is further inland off the peninsula. Here the annual rainfall may be as low as 50". The leaves were turning yellow and falling, and very few pods were seen. Elsewhere the trees were carrying a good crop.

Cacao is always grown under heavy shade, with "Anauca" Immortelles (*Erythrina micropteryx*) predominating. Unlike Trinidad, however, other shade trees are used, particularly "Apamate" or "Pink Poui", (*Tabebuia pentaphylla*). The presence of mixed shade has undoubtedly saved the cacao on many estates where the Immortelles have died from an obscure disease.

The cacao appears at first sight to be similar to the Trinitario type grown in Trinidad. After more thorough observation we decided that red pods are even more common than in Trinidad, and that they are generally bigger and perhaps smoother. This would account for the bean size of "Trinidad Caracas" (as this cacao is marketed) being bigger than that of "Trinidad Estates". In many estates the predominant type of pod resembles that of the clone I.C.S. 1, illustrated in the *Third Ann. Rep.* of the Cacao Research Scheme, Trinidad. The yields appeared to be greater than in Trinidad, with the crop more evenly distributed among the trees. Very few pale beans were seen in the many pods opened. It is surprising that this type of cacao should produce such good cacao with no fermentation whatever; the raw beans and pulp are spread directly on the drying trays, and yet few slatey beans were found in dried cacao.

Pollination

Many pollinated flowers and young cherelles were examined, and the majority carried the ball of pollen characteristic of pollination by the Ceratopogonid midge,† *Forcipomyia* spp. No specimens were collected, but it is probable that cross-pollination prevails as in Trinidad, and that the same insects are responsible.

* Permuy, M.G. (1922) "Trinidad Cacao and Trinidad Caracas". *The Spice Mill*, Vol. 45, p.2332, (Quoted by Van Hall, C. J. J. "Cacao" 1932. p.330).

† Billes, D. J.—Pollination of Theobroma Cacao L. in Trinidad, B.W.I. *Tropical Agriculture*, XVIII No. 8, pp. 151-156, 1941.

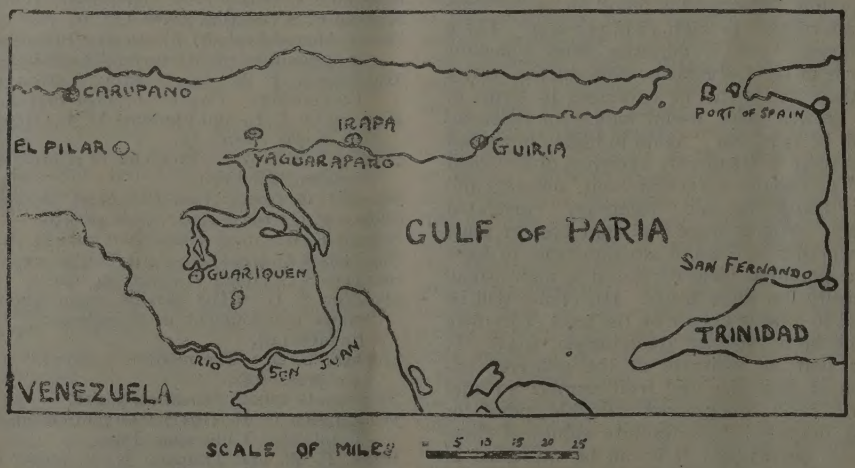

FIG 1. MAP OF THE PARIA PENINSULA, VENEZUELA.

Immortelle Disease

Throughout the whole length of the peninsula the "Anauca" Immortelles are being killed by a disease unknown in Trinidad. This disease was first investigated by Palma in 1940, but peasants claim to have seen it five years before. Judging from its wide distribution the disease may have started much earlier on the peninsula and only recently reached El Pilar, where few infected trees were seen. No control measures have been attempted. The "Bucare" (*Erythrina glauca*) appears to be immune. Where the two are grown together only the "Anaucas" are affected, although the conditions are generally less suitable for "Bucare" than for "Anauca". *Erythrina colladodendrum*, used for fences, is also susceptible. The loss of practically all the "Anaucas" is a calamity of the first magnitude; it is the most serious problem affecting cacao in this region. Since there is an obvious possibility of this disease reaching Trinidad, planters would be well advised to cease using pure stands of "Anauca", and to turn to either a mixture of shade trees or another species.

Symptoms. The first sign of the disease is the appearance of Witches' Brooms or galls on the branches of the Immortelle; later brooms may appear on the trunk. Trees of all ages are attacked. Each broom is composed of many leafy shoots growing from the same base; bud-stimulation is prolific, resulting in a mass of small twigs. Die-back starts after 4 or 5 weeks and as the tips of the shoots die, others grow from nearer the base of the broom. The brooms increase in size and number until the tree is festooned with them, (200 have been counted on one tree). Eventually the broom dies and then die-back spreads back along the branch. After most of the branches have been killed the tree dies; the interval between first infection and the death varies according to the size of the tree, saplings being killed in about six months and big trees in about two years. Damage is similar in the mountains and on the plain, and no marked seasonal incidence has been observed.

A tip borer, the larva of a moth, is often found in the brooms, but as it is also found in shoots without brooms, and many brooms are not attacked, it is unlikely that the borer is the cause of the brooms. Two years after borer attack, a small tree had developed no brooms. No fructification or mycelium was found on the brooms; moreover it seems improbable that a localised fungal infection would kill the tree so rapidly. Possibly the brooms are a manifestation of a systemic virus infection.

The disease warrants a full investigation by a plant pathologist, in order to discover the pathogen and possible means of control. In the meantime it is futile to continue the planting of "Anauca" Immortelles as shade for cacao.

Witches' Broom Disease

Around Guiria and Irapa the incidence of Witches' Broom (*Marasmius perniciosus*) on cacao is remarkably low. A few infected pods were seen, but no brooms were found during the writers' thorough search (brooms are not removed when they occur). It is surprising that the disease is not more serious and this was first attributed to general low humidities as compared with Trinidad, an assumption partly supported by the epiphytic flora. Palma has observed no change in the incidence of the disease during the past 5 years.

Around Yaguaraparo the conditions are very wet, but again the incidence of Witches' Broom is very different from that in Trinidad. Counts on pod heaps revealed about 7% pod infection, and it appears to be even higher among pods still on the trees. Vegetative brooms were absent from practically all trees, but scattered through the fields were found a few trees (perhaps 2%) literally covered with cushion brooms and with many fan and chupon brooms. This proved that conditions were suitable for infection, and the most reasonable explanation appears to be that about 2% of the trees are susceptible, while the rest possess a high degree of resistance to infection, except for pod infection. The few susceptible trees must supply the spores which infect pods throughout the field.

It seems clear that the disease should be completely controllable by the removal of comparatively few susceptible trees, which are worthless since they bear few pods, all infected. This should raise yields at least 5% by eliminating the loss of pods from Witches' Broom on the remaining trees.

The presence of a resistant population of what appears to be high quality Trinitario trees should be of direct interest to Trinidad. In the Orinoco delta and in the "canos" of the Paria Gulf (Guariquen), Palma has observed the reverse, with infection widespread and occasional trees without brooms. This resembles the condition in most Trinidad estates, and round El Pilar also, infection was scattered over most of the trees. It suggests that the cacao populations of Trinidad, Guariquen and El Pilar are similarly susceptible to Witches' Broom while that round Yaguaraparo reacts differently. As already stated no differences are obvious, except that there is less variation in the Yaguaraparo population and the mean is shifted towards bigger, smoother, and more often red pods. It also suggests that the reason for light infection near Irapa was not environmental, but due to resistance, although no heavily infected (susceptible) trees were seen in that locality.

Virus Diseases

Because of the recent discovery of virus diseases of cacao in Trinidad (Posnette, *Trop. Agriculture* 21, 6, 105-6.) the main object of the visit was to investigate the possibility of its spread from Venezuela. Sufficient cacao was inspected in the localities named to indicate that this virus is either absent or very rare.

Without transmission tests it is unwise definitely to attribute leaf symptoms to a virus infection. On nearly every estate a few trees were seen with leaf mosaic resembling virus symptoms, but quite distinct from the Red Mottle and the Vein-clearing types found in Trinidad. These trees occurred

singly, occasionally in pairs, scattered through the fields. Old and young leaves on most of the branches showed a yellow mosaic, sometimes affecting only part of the leaf. No stem swellings or pod mottle was observed. No insects were found confined to the trees showing these symptoms, which could be distinguished from lesions caused by insects (probably Jassids and Membracids) found on most trees both in Venezuela and Trinidad. The distribution of affected trees suggests that an infection, rather than insect attack or soil condition is the cause.

Most trees with mosaic were showing some ill-effects : usually the leaf-canopy was reduced, the yield poor, and in a few cases dieback had started. The incidence of the disease is so slight that it does not present a serious problem. The wide distribution suggests that it is long-established and the spread within a field very much slower than that of virus diseases of Trinidad and Gold Coast cacao.

Summary

1. The type of cacao grown on the Paria Peninsula, particularly that near Yaguaraparo, may be more resistant to Witches' Broom disease than Trinidad cacao.

2. The most serious threat to the cacao industry of that region is a disease of the shade trees, the cause of which is unknown. The symtoms are described.

3. Virus diseases of cacao are rare ; symptoms of a possible new virus disease are described.

TROPICAL BUTTER-FAT SPREAD

Dr. W. F. Wiley, of the Australian Council for Scientific and Industrial Research, is mainly responsible for the discovery and research work entailed in the production of tropical butter fat spread. The consideration which led to the development of this product was the necessity for replacing butter by a substitute to withstand a combinaton of high temperatures and lack of refrigerated storage. Putting butter in tins does very little to remove the disadvantages from which butter suffers in hot climates. Unlike other tinned foods, tinned butter has undergone no sterilizing or preservative treatment. When subjected to high temperatures, bacterial deterioration takes place, particularly if the butter melts and the fat and serum separate. Under these conditions, rancid, putrid or cheesy flavours develop in a few weeks, often making the butter inedible. The physical condition of the butter is also unsuitable in such climates ; it has to be poured rather than spread. The main cause of deterioration which has to be guarded against is oxidation. This is done by removing air from the product during manufacture (butter contains about 6 per cent. of air), and the tins are sealed under vacuum. Control of texture is based on rate of cooling.

Tropical butter-fat spread is manufactured from creamery butter. This is melted with live steam, and the melted butter is run into large neutralizing and mixing vats. After neutralization has taken place, the melted butter is run through high-speed centrifuges where the pure-dry butter-fat is separated from the water, salt and curd. The pure fat is then boiled under vacuum and partly cooled before being run into the mixing vat. To the pure butter-fat is added a small quantity of finely powdered salt, skim milk powder, diacetyl flavouring, and 19 per cent. of hydrogenated butter-fat, which increases the melting point of the product to about 105°F.

After thoroughly mixing the ingredients, the spread is then de-aerated in a vacuum chamber and shock-cooled under vacuum before it is packed into 1-lb. or 5-lb. cans. These cans are sealed under vacuum to exclude any air in the container. The spread will not melt at a temperature below 105°F. Even if higher temperatures are encountered and the product should melt, thus causing the salt and skim milk powder to settle out, these ingredients can easily be re-incorporated by stirring.

New Zealand practice in manufacturing pure butter-fat follows much the same course, but there are differences in detail. The butter is melted by direct steam and is separated by gravity into fat and serum. The serum is centrifuged to remove fat, which is added to the bulk. There is no caustic soda treatment ; the fat is melted and run serially through two whey separators, which reduce the water content to 1-2 per cent. and non-fatty solids to 0.1-0.2 per cent. The fat is then run directly into a vacreator, which reduces the water to under 0.1 per cent. and thence through a centrifugal clarifier to reduce the non-fatty solids.—(Abstracted from *Modern Refrigeration*, Vol. 47, No. 551 and *Dairy Industries*, Vol. 9, No. 2, 1944).

STORING SWEET POTATOES

It is well known that sweet potatoes rot very rapidly after being dug, especially in the hot weather. The following experiment indicates a method of preserving them indefinitely.

About 50 lb. weight was put in a drum on 17th July 1942, with alternate layers of fresh wood ash. Monthly tests indicated that they were keeping well. The drum was finally tipped out on 27th November and only two or three small potatoes were found to be decomposed. A native method of storing sweet potatoes is to dig them in August—dig a hole in the ground, put in a layer of sand, then fill the hole with alternate layers of potatoes and wood ash, finally covering with earth. It is claimed that by this method sweet potatoes keep in good condition until the following February.—(*The East African Agricultural Journal*, Vol. IX, No. 2).

HAY-MAKING UNDER CONDITIONS OBTAINING IN THE DRIER WEST INDIAN ISLANDS

BY

C. A. S. HYNAM AND L. R. HUTSON

(*Agricultural Assistant, and Chief Veterinary Officer, Department of Agriculture, Antigua, B.W.I.*)

Introduction

The general practice in most West Indian islands is to keep stock on pastures throughout the year. Stall feeding is rare and usually no attempt is made to conserve fodder. Since, however, climatic conditions are such that there is usually an abundance of fodder in the "wet" season, which lasts in general about six months, and a shortage very often acute, in the subsequent dry period, practical methods of fodder conservation are a very real need.

The information in this article is based on the results of work carried out in recent years in St. Maarten, Netherlands West Indies, and in Antigua.

In St. Maarten the export of hay to Curacao started during 1938 when 37,865 kilograms were shipped from the island. Exports had increased to 203,950 kilograms during 1941 and were still on the increase when shipping difficulties arose and practically stopped the trade. The hay was used as a maintenance ration for cattle and horses in place of more expensive products which had been imported from Chile and the U.S.A. No comparative analyses were obtained, but up to 1941 when one of us connected with the work in that island left it, no unfavourable reports as to the feeding qualities of the hay had been received.

It should be recorded that during the years referred to, the exportation of relatively large amounts of conserved fodder did not result in there being a more acute shortage in St. Maarten during dry periods: actually there was a marked improvement in the fodder situation at such times, thus indicating that the additional amount made available by the adoption of conservation methods was in excess of that exported.

In Antigua the rainfall averages about 43 inches per annum, temperatures rarely fall below 70°F. or rise above 90°F. in the shade, and the relative humidity is usually between 70 and 80.

In St. Maarten the average rainfall is about 40 inches. No figures are available for temperatures and relative humidity but the climate is much the same as that of Antigua.

Grasses Used

In St. Maarten Guinea Grass, *Panicum maximum* and to a lesser extent Para or Shand Grass, *Panicum mutica*, were used. In Antigua, where only small scale trials have been conducted, Hay Grass, *Andropogon caricosus*, was used exclusively.

Under conditions obtaining in St. Maarten and on the lighter and better drained Antigua soils, Guinea Grass is common in the wild state, but greatly increased yields can be obtained if the grass is properly cultivated. Para grass in these islands is found growing wild only in moist localities, *e.g.* around the edges of ponds, but in St. Maarten excellent growth in pure and even stand has been obtained in well cultivated fields in relatively dry situations.

In 1894 Barber (1) wrote about Hay Grass in Antigua as follows:—

> "Specimens sent to Jamaica and Kew for identification were differently named, but assuming the Kew determination to be correct, it appears to be *Andropogon caricosus*. I do not at present know it in any other West Indian islands, and some surprise was expressed at Kew at its presence in Antigua, because it is an East Indian species. It would be an interesting puzzle to determine how it found its way into our island. It is known locally as "hay grass" and if cut at the right time should prove to be a very valuable fodder "plant".

This grass is now probably widely distributed among the West Indian islands. It has recently been identified in Nevis, and following its introduction from Antigua it is now well established in a dry section of Grenada.

It seems well adapted to conditions obtaining on the heavier poorly drained Antigua soils where it quickly takes possession of uncultivated lands and at times a surprisingly pure stand can be obtained on self sown areas with no preparation of the land other than the removal of the tougher and taller shrubs &c.

Process

The method employed is the same for the three grasses used, except with regard to the length of time required for "making". Guinea and Hay grasses in St. Maarten and Antigua require only 20-30 hours of sunny weather, while Para Grass requires from 60-70 hours. Guinea and Hay grasses should be cut just before the seeds begin to form and Para grass before the stems become fibrous.

The grass is cut in bunches, spread out as thinly as possible in the field and arranged so that each day's cutting can be easily identified (Fig. 1). The cutting instrument used locally was an ordinary sickle or grass knife. The maximum area cut by one woman in Antigua during a recent trial was approximately 1/7 acre per day.

After being cut and spread the grass is turned at regular intervals—at least once per day if the weather is good, or more often if it is damp or showery. Regular turning is of the utmost importance, otherwise the produce becomes mouldy and unfit for storage.

The object in "making" is to reduce the moisture content without causing the grass entirely to lose its green colour. Excessive exposure to sunlight produces a harsh brittle product. This is particularly so in the case of Guinea grass. On the other hand when the product is insufficiently dried before storing, heat is generated in the bale or stack and spoilage is rapid.

As soon as the desired stage is reached, the hay is raked into small loose heaps and taken thence as soon as possible to stacks, covered barns or sheds.

Hay made from *Andropogon caricosus* by the process outlined above is of finer quality than that made from either Guinea or Para grass.

Storing

(*a*) *Bales*. Baling may be done by means of hand operated cotton presses (Fig. 2) or by a steam operated bagasse baler.

In order to obtain well shaped bales with the hand press it is found necessary to put the grass in the press in even layers and trample each layer well before compression. Stout wire is used to keep the bales together. The bagasse baler was used experimentally only with Andropogon hay and worked very satisfactorily. The hay was well compressed into bales of convenient size averaging 112 lb. each.

(*b*) *Stacks*. Stacking in the field obviates the necessity of restricting output to the capacity of farm buildings, and if the animals are not stall fed it may reduce transportation charges. On the other hand stacking in the open increases the chances of spoilage, and decreases the length of time during which the hay can be kept.

The information on stacking given below refers only to Andropogon hay.

In the Antigua trials three types of stack were built. (Figs. 5, 6, and 7.). In all three cases the stack was constructed on a "staddle" Figs. 3, and 4, made by building up layers of logs about 2 inches in diameter, lighter wood and finally (on top) brushwood to a height of about 2 feet so as to allow air to circulate below it and thus prevent the lower layers of hay from coming into contact with the damp soil.

In building the stacks, successive layers of hay were vigorously trampled by workers standing on the growing pile, taking care to maintain the desired shape. This was easiest in the case of the stacks illustrated in Fig. 5, as hog fencing supported by posts formed a framework which kept the hay in place. The shape most difficult to maintain without the assistance of a framework was that of the one with perpendicular sides (Fig. 7). The dome shape (Fig. 6) can be obtained without much difficulty by confining the trampling more and more to the centre of the heap as it grows in height.

As the stack settled, grooves and openings tended to form on the roofs and sides through which water seeped during showers. These were filled in with quantities of the hay itself.

It is estimated that a stack built as in Fig. 5 on a staddle 10 feet by 12 feet in surface area, with perpendicular sides 7½ feet high and a roof whose peak was 9¼ feet from the ground will contain approximately 6,000 lb. of well trampled newly made hay.

In choosing a site, attention to drainage is essential. It is advisable to provide a drain around the stack with a lead off so as to dispose of any water which might collect at the base.

Keeping Qualities and Palatability

Experience in St. Maarten indicates that it is inadvisable to store Guinea Grass hay for longer than three months: after this period it becomes somewhat trashy and brittle with the result that there is considerable loss if bales have to be transported any distance. On the other hand Para grass bales made with the hand press may be kept in storage for periods up to six months without tending to disintegrate on handling.

The Antigua made Andropogon hay was stored in a dome-shaped stack (Fig. 6) which was fully exposed to the weather for 20 months. During this period 93.05 inches were recorded at a station about one mile away from the stack. This includes the following falls recorded within 24 hour periods:

Inches	*No. of occasions*
3.80	1
3.00	1
2 to 2.5	3
1.5 to 2.0	3
1.0 to 1.5	15

The relative humidity for 14 of the above-mentioned 20 months (figures for the remaining six not available) varied between 68.0 and 81.0 with an average of 75.5.

At the end of the period the hay was found to be in excellent condition except for a layer about 4 inches thick on the top and sides which was spoiled owing to excessive bleaching.

When the stacked hay was being fed, the stack was opened on the lee side and the hay removed in vertical sections as required.

Baled Andropogon hay was examined after being in storage under cover for over a year. All the bales were in perfect condition throughout. It was noticeable that the baled hay retained its characteristic aroma longer than the stacked hay.

Andropogon hay was fed to cattle, horses, mules, donkeys, sheep and goats. It was readily eaten both in the fresh state and after being stored in bales and stacks for the above-mentioned periods.

Yields

Yield figures are available only for Andropogon trials in Antigua.

In one trial a neglected field on poor land containing grass of uneven stand averaging about 20 inches in height yielded 3,609 lb. of baled hay. Spoilage and wastage was estimated at 10 per cent. thus indicating a yield of about 1.8 tons per acre.

FIG. 1. Showing cut grass being sunned in the field and an uncut stand of *Andropogon caricosus* (Hay Grass).

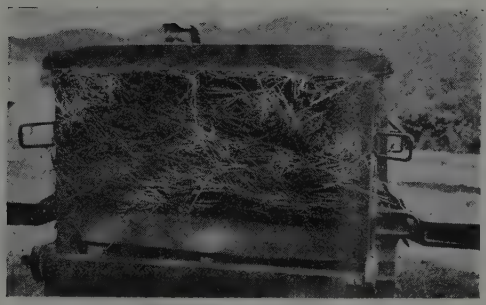

FIG. 2. Cotton baling press used for baling hay in St. Maarten.

FIG. 3. Showing foundation of staddle which is made of logs and brushwood.

FIG. 4. Showing staddle with first layer of hay.

FIG. 5. Stack supported by wire framework.

FIG. 6. Dome-shaped stack.

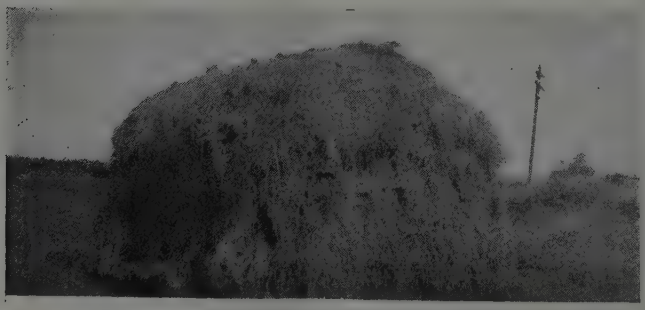

FIG. 7. Stack with perpendicular sides.

More exact figures were obtained from a four acre field (Fig. 1) of pure and even stand, about 3 feet high. Grass was cut from four lots each 40 feet by 40 feet. The average yield per lot was 676 lb. or at the rate of 8.2 tons grass per acre.

As a result of weighing a sample before and after twenty hours full exposure to sunny weather it was found that there was a loss of 35 per cent. in weight. On this basis the weight of hay obtained from the above plots would be at the rate of 5.4 tons per acre.

A well replicated manurial trial on a self-sown field on poor land resulted in a yield of 5.16 tons hay per acre from the manured as against 3.12 tons from the un-manured plots. Artificial manure was applied at the rate of 2 cwt. Ammophos per acre.

Statistical analysis of individual plot yields showed the difference of 2.04 tons to be significant.

Production Costs

During 1940 baled St. Maarten hay was sold wholesale in Curacao at around 2.50 guilders per 50 kilogram bale (6s. 8d. per 110lb. at the then current rate of exchange).

From this amount the equivalent of about 2s. 8d. was deducted to cover the costs of lighterage, freight &c.. No exact figures for cost of production are to hand, but the balance of about 4s. per bale was considered to yield a good profit by producers paying unskilled labour about 2s. 8d. per day.

During a recent trial in Antigua the cost of cutting, preparing and stacking twenty-four tons of hay was £25, or at the rate of 19s. 2d. per ton.

It is considered that with improved technique and labour saving devices the above cost could be considerably reduced.

Summary

(1) A method of making hay from Guinea Grass, *Panicum maximum*, Para or Shand grass, *Panicum mutica*, and Hay Grass, *Andropogon caricosus* is outlined.

(2) Of the three grasses Hay Grass was found to give hay of the finest quality.

(3) *Andropogon caricosus* hay stored in compressed bales and open-air stacks for periods up to one year and twenty months respectively, retained its soundness, texture and palatability.

(4) *Andropogon* hay was fed to cattle, horses, mules, donkeys, goats and sheep—all of which ate it readily.

(5) The cost of cutting Hay Grass, preparing the hay and stacking same under Antigua conditions with unskilled labour is given at 19s. 2d. per ton. At no stage was any labour saving device used.

Acknowledgments

The generous assistance of the Antigua Sugar Factory in carrying out a baling experiment with their bagasse baler is gratefully acknowledged.

Reference

1. Barber, C. A. Notes on Antigua Grasses. *Supplement* to *Leeward Islands Gazette* of 4th October, 1894.

SOIL STRUCTURE AND TILLAGE *

BY

A. G. POLLARD

Increased interest in soil structure in relation to systems of cultivation, erosion, soil-water relationships, etc. has focussed attention on the measurement of the state of aggregation in soils and its implications. Sieving and sedimentation methods held sway for some time in spite of some indecision as to the appropriate means of breaking down unstable aggregates without disruption of stable aggregates. A better appreciation of the nature and significance of gross aggregate structures and of the water-stability of aggregates has clarified the position. E. W. Russell and R. V. Tamhane (1) have examined a number of methods of aggregate analysis and of sampling and draw a clear distinction between "clods" i.e., aggregates or lumps occurring as isolated entities in the soil, and water-stable aggregates or crumbs. The apparent size distribution of these varies somewhat with the technique adopted in their examination. Dry sieving gives a satisfactory graduation of clods, except in very wet sticky soils, and crumbs are graded by wet sieving and, for very fine fractions, by sedimentation. For more accurate observations crumbs are separated from sand particles by flotation in a solution of bromoform in carbon tetrachloride, the density of which is suitably adjusted.

Following up his earlier work, D. I. Sideri (2) has investigated the macro-structure of soils by the microscopical examination of polished sections and in this way has traced the effects of cultivation, manuring, etc. on structural changes. He indicates also that the technique is satisfactory for studies in soil morphology. G. C. Redlich (3) also adapts Kubiena's thin-section microscopical method (4) to the direct measurement of the size distribution of soil aggregates and expresses the structure of soil in terms of the "soil quotient" i.e., % pore space × 100 ÷ % of crumbs exceeding 1600μ in diameter. By this means the effect of manuring on soil structure is clearly

*Reproduced from the *Ann. Reps. Soc. Chem. Indus., Progress of Applied Chemistry*, XXVI, p. 363.

shown and is expressed numerically. G. W. Volk and H. J. Haifa (5) prepared soil sections for microscopical examination by impregnation with bakelite varnish and subsequent heating until the varnish hardens; sections can then be cut and polished.

The microscopical method is also applied to the determination of water-stable aggregates in soil by J. W. Peterson (6). After slaking the sample in water for six hours the water is siphoned off and replaced by glycerol with which the soil suspension is then uniformly mixed. An aliquot of the suspension is then transferred to a crystallising dish and after settling the size distribution of the aggregates is ascertained directly. The mechanical analysis of the sample for particles larger than clay is determined similarly after dispersion.

A. N. Puri and B. R. Puri (7) also represent the state of stable aggregation in soils as a single numerical value. They calculate the "weighted mean" size of soil particles from summation curves for the sample before and after dispersion, and express the state of dispersion as the ratio of these two values. Another method of representing the state of aggregation as a single value is described by R. B. Alderfer and F. G. Merkle (8). Curves showing the percentage of fractions of different diameters are prepared for the aggregate and mechanical analyses of the soils. Since the aggregate analysis must contain the larger proportion of coarser particles and the smaller proportion of fine particles the two curves will intersect. The difference in the summations of percentages in aggregates and mechanical analyses of particles exceeding the diameter at the point of intersection, i.e., the summation of all positive differences between the aggregate and mechanical values, expresses the "structural stability" of the soil.

Certain aspects of soil aggregation in relation to erosion (9) and to soil porosity (10) have been referred to in earlier Reports. Recent investigations of the influence of methods of cultivation and cropping on the aggregate structure are of interest, and tend to support the view that aggregate analysis may well become a soil characteristic of considerable importance. For example, R. S. Stauffer, R. J. Muckenhirn, and R. T. Odell (11) show that permanently grassed soils contain in the surface (6-in.) layer a far greater proportion of aggregates of diameter exceeding 0.5 mm. than similar cultivated soils, and that a maize-oats-clover rotation caused some increase in larger aggregates as compared with a maize-oats or a continuous maize system; effects of cultivation on aggregate structure were limited to the upper 9-inch layer. These observations differ somewhat from some made earlier by W. H. Metzger and J. C. Hide (12), who report that in the soils examined grasses were less effective than clovers in increasing soil aggregation and also that the effect of a limed clover crop exceeded the sum of the separate effects of clover and of liming. The association of organic matter contents and soil pH with changes in aggregation is indicated in this and many other investigations. The species of the grasses also appears to be an important factor, annual species tending to diminish and perennial species to favour the formation of larger stable aggregates (13). C. M. Woodruff (14) associates stability of aggregates with cropping systems which preserve the organic matter content of the soil and takes the view that the state of aggregation depends more on the cropping history than on the properties of the original virgin soil. This is further confirmed by J. L. Retzer and M. B. Russell (15) in an examination of the structural stability of soils of different types. Differences between aggregate analyses of soils of the same type but of different history are shown to be sufficiently great to obliterate differences between types. H. Burgevin and S. Henin (16) find that the continuous use of artificial fertilisers over a period of years results in a marked degradation in soil structure.

The part played by organic matter in the formation of stable aggregates is widely recognised. In general the incorporation of comminuted crops in soils tends to produce the same effect as the growth of the actual crop in the soil. Well aggregated soil fractions are found to contain more carbon and nitrogen than the loosely aggregated material (17). Aqueous extracts of straw which contain pectins, proteins, and carbohydrate material are shown by A. I. Schtschukina (18) to increase the size of soil aggregates; the product obtained by autoclaving lignin with sodium hydroxide solution proved even more effective in this respect. G. V. Davidov (19) correlates stable structure in soil with the presence of organic gels. That the character of the organic matter as well as the proportion present in soil influences the state of aggregation is further confirmed by J. L. Retzer and M. B. Russell (20), who failed to establish any relationship between the degree of aggregation and the percentage of total carbon or of clay. These authors also report that the addition of sugar has a greater effect in improving aggregation than has the incorporation of plant materials. This accords with observations made by J. P. Martin and S. A. Waksman (21), who demonstrate that the rapid growth of micro-organisms following the admixture of organic matter with soil has a marked binding effect on the soil particles, the degree of aggregation induced being directly related to the ease of decomposition of the material added. The binding action is ascribed to organic compound synthesised by bacteria and to the production of a network of fungal mycelium around groups of soil particles. The action of lime in improving aggregation is dependent on its effect on the organic material present. The relation between aggregation and bacterial activity is further examined by H. E. Myers and T. M. McCalla (22), who find that the maximum increase in aggregation following artificially stimulated bacterial growth does not coincide with but lags behind the development of maximum bacterial numbers.

Aggregation is regarded as being brought about by products of bacterial metabolism. The effect is independent of pH in the range 4.1-6.7. J. Elson (23), in a study of the influence of cropping on aggregation, points out that the percentage aggregation calculated on aggregates larger than 0.1 mm. with allowance for the proportion of sand particles exceeding 0.1 mm. gives a less perfect picture of the state of aggregation than does the the size distribution curve and the "relative surface" determined by Cole's method (24).

Although soil aggregation doubtless involves other factors than organic matter it would appear that changes in the structural condition of individual soils resulting from manuring and cropping are to a large extent dependent on bacterial by-products.

References

1. E. W. Russell & R. V. Tamhane; *J. Agric. Sci.*, 1940, 30, 210; B., 1940, 556.
2. D. I. Sideri; *Soil Sci.*, 1938, 46, 337; B., 1939, 414.
3. G. C. Redlich; *Ibid.*, 1940, 50, 3; B., 1941, III, 1.
4. Kubiena; *Ann. Repts.*, 1939. 24, 486.
5. G. W. Volk & H. J. Haifa; *Soil Sci.*, 1939, 48, 141; B., 1939, 1270.
6. J. W. Peterson; *Ibid.*, 1940, 50, 331; B., 1941, III, 223.
7. A. N. Puri & B. R. Puri: *Ibid.*, 1939, 47, 77 B., 1939, 974.
8. R. B. Alderfer & F. G. Merkle; *Ibid.*, 1941, 51, 201; B., 1941, III, 313.
9. A. G. Pollard; *Ann. Repts.*, 1938, 23, 571.
10. ——————— *Ibid.*, 1940, 25. 421.
11. R. S. Stauffer, R. J. Muckenhirn & R. T. Odell; *J. Amer. Soc. Agron.*, 1940. 32. 819.
12. W. H. Metzer & J. C. Hide; *Ibid.*, 1938, 30, 833; B., 1939, 528. Also J. C. Hide & W. H. Metzger, *Proc. Soil Sci. Soc. Amer.* (1939), 1940, 4, 19; B., 1941, III, 141.
13. I. P. Sarachov; *Pedology*, 1938, No. 10, 1264; B., 1941, III, 90.
14. C. M. Woodruff; *Proc. Soil Sci. Soc. Amer.*, (1939), 1940, 4, 13; B., 1941, III, 141.
15. J. L. Retzer & M. B. Russell; *Soil Sci.*, 1941, 52, 47; B., 1942, III, 6.
16. H. Burgevin & S. Henin; *Ann. Agron.*, 1939, 9, 771; B., 1941, III, 3.
17. *Loc. cit* (16).
18. A. I. Schtschukina; *Proc. Conf. Soil Sci. Saratov*, 1937, 1, 118; B., 1939, 301.
19. G. K. Davidov; *Pedology* 1940, No. 3, 81; B., 1941, III, 141.
20. J. L. Retzer & M. B. Russell, *Loc. cit.* (15).
21. J. P. Martin & S. A. Waksman; *Soil Sci.*, 1940, 50, 29, B., 1941, III, 2.
22. H. E. Myers & T. M. McCalla; *Ibid.*, 1941, 51, 189; B., 1941, III, 312.
23. J. Elson; *Ibid.*, 1940, 50, 339; B., 1941, III, 23.
24. Cole; *Hilgardia*, 1939, 12, 429.

SOIL ORGANIC MATTER

Among papers of interest relating to the nature and formation of humus materials is that of W. S. Gillam[1] in which is recorded an examination of the humic acids (ammoniacal extracts) of a grey-brown forest soil, a muck, and a grassland soil. The main chemical and physical properties of all three samples were similar and corresponded closely with those of the slightly modified lignin complex separated from a prairie soil by alcoholic caustic soda. Each of the three acids was mono-carboxylic and contained hydroxyl groups which exhibited no base-exchange capacity yet the exchange capacities of the whole acids were high in each case. The humic acids contained 34-38 per cent. of protein-like material. The effects of acetylation and methylation confirm the very close relation of the non-nitrogenous portion of humic acid with lignin. It is probably lignin slightly modified by demethylation, hydrolysis, or other minor reactions resulting in the formation of phenolic and carboxyl groups.

An unusual type of alkaline raw humus is described by H. M. Galloway[2]. The sample occurs on calcareous outcrops in a podsol belt and apparently originates from vegetation normally associated with strong acids. Its high lignin and hemicellulose and low cellulose and ether and alcohol soluble contents, together with other chemical data recorded, suggest that alkaline raw humus is genetically an intermediate between an acid raw humus and a low-moor peat. The influence of rainfall on the character of humus formed is examined by R. H. Fowler and L. C. Wheeting.[3] The principal points emerging are the general relations of the mean rainfall to the C/N ratio and to the total nitrogen content of the organic matter, wide C/N ratios and low nitrogen contents being associated with high rainfall. According to studies reported by H. F. Salisbury and W. A. De Long[4] the cultivation of forest soils leads to a diminution in total organic matter content, a slight increase in protein resistant to hydrolysis and of non-amide nitrogen in hydrolysates, and small diminution in the proportion of lignin and hemicellulose. The humus of fossil soils (chernozem and podsol) when compared with the corresponding surface soils shows evidence of further slow decomposition after the soils had been buried. I. V. Tiulin and E. I. Tiurina[5] make the interesting observation that while buried chernozem humus showed little change in nature and composition, buried podsol humus suffered decomposition of the readily hydrolysable fractions, leaving a residual material similar to chernozem humus. It is concluded that chernozem humus represents a stable system; to a large extent it acts as a single organic complex substance.

Referenes

1. *Soil Sci.*, 1940, 49, 433; B., 1940, 884.
2. *Ibid.* 295; B., 1940 816.
3. *J. Amer. Soc. Agron.* 1941 33, 13; B., 1942 III, 65.
4. *Sci. Agric.*, 1940, 21, 121; B, 1942, III, 41.
5. *Pedology*, 1940, No. 2, 10; B., 1941, III, 86.

(From *Annual Reports of the Society of Chemical Industry on the Progress of Applied Chemistry* 1942, Vol. XXVII, by A G. Pollard.)

AGRICULTURAL DEVELOPMENTS IN THE U.S.S.R. *

Prior to the Revolution the three systems of farming practised in the U.S.S.R. included large estates; small peasant farms; and peasant land farmed by the peasants under the *Mir*, the village Council or commune of very ancient origin.

Some of the large estates were run on good modern lines, some were put into the hands of managers whose business it was to extract all they could for the owner, others were moderately well managed. The peasant farms were small holdings owned by the individual farmers, which had resulted from the various agrarian reforms, the most important of the later ones being those of Stolypin (1905), who had a Danish adviser and was aiming at the Danish model. The peasant land under the commune (nadiel land) belonged to the body of peasants but not to any individuals; it was parcelled out into many strips which were periodically distributed by the *Mir* among the peasants in accordance with the size of family, etc. These strips were scattered over the whole area so that each man should have his share of good and of bad soil. In the time of the Revolution it was estimated that about 45 per cent. of the cultivated land was in the hands of the peasants.

All three systems were disliked by the Bolsheviks, the first two because they involved private ownership of land, and the third because of its grave inefficiency and the utter impossibility of introducing modern improvements. The Bolsheviks also disliked the peasant mentality, so utterly different from that of the factory worker. The peasant wanted to sell his products at high prices while the factory worker wanted to buy them cheaply. The factory worker was accustomed to work in masses for an employer, and had before the Revolution no sense of proprietorship: the peasant was used to working alone or in small groups and always felt that he owned the land he tilled.

After some experiments, State farms were set up which accorded well with Bolshevik theory. The peasants were employees of the State receiving a weekly wage, living in great blocks of dwellings in a central area developed like a town. The whole organization resembled that of a factory, and it was expected that the peasants would develop the factory workers' outlook and become one with them. But the peasants did not like them and so they never developed: in 1938 only about 10 per cent. of the cultivated land was worked as State farms, and they were used for special purposes. A completely different type of farm was set up, on the basis of the old *Mir*. The first were communes in which the whole body of workers was responsible for the full maintenance of each individual family; but this did not answer. The *artel* organization was therefore adopted: another old Russian method which has no English equivalent. In this the workers feed and house themselves but the produce belongs to them, and after all outgoings have been met the balance is distributed according to the work done. The workers are paid in actual produce: mostly grain, potatoes, and vegetables, these being the main constituents of the peasants' dietary; usually also there is hay for the workers' animals, and a small amount of cash. This method after suitable modification proved much more acceptable, and by 1939 a very large part of the cultivated land of the U.S.S.R. was farmed in this way.

The farms were called "Collectives". All the cultivated land in the village, whatever its previous ownership, was thrown into one big farm: it might be 1,000-4,000 acres or more, but was not usually unmanageable in size. All the peasants of the village could come into the group, but preference was given to the so-called "poor peasants". The plan of production was until just before the War sent from headquarters: it had been discussed during its development, but once settled, it could not be further discussed. The workers elected a committee to carry it out and to allocate the tasks to the different people; the chairman, however, was not freely elected as he had to be accepted by the Party and the Government; he often came from outside and did not usually stay long. The Party always insisted on keeping its hold on the farms, and it had its representative, who was quite independent of the committee.

Payment was always by the piece; a certain job of work was called a "labour day", and when a man had done this he was credited with one day's work. Not infrequently about two hundred would be done during the year, but specially good workers would put in many more. The worker could eat his share of the produce or sell it to the farm, the Co-operative or in the peasant market.

The workers' share of the produce varied with the yields and the out-goings. The Government's share has varied. For some time prior to 1939 it was a fixed amount per acre of winter grain sown, and of spring grain ordered to be sown, also a fixed quantity of milk and meat per animal kept. A small price was paid, much below the market price. In 1939 more latitude in planning was allowed so long as the stipulated Government share was duly delivered. As this was fixed while yields were variable it is impossible to state any definite percentage; but an average of a number would lie between 15 to 20 per cent. Then the machine tractor station, the Government organization that hired out the tractors, combines and other big tackle and supplied the drivers had to be paid: this might take another 15 per cent. Seed for next season and fodder for winter had to be set aside: this also might amount to about 15 per cent. Insurance,

* Article by Sir John Russell, F.R.S., reproduced from *Nature*, Vol. 152, No. 3862, p. 525.

administration, sick and needy people, maintenance, capital developments, and other farm overheads had also to be provided. One way and another, more than half the produce would go, and the workers' share might be 40 per cent. or less.

A great change in the system, and in the peasants' attitude to it, came when the Constitution of 1936 gave the Collective farms the use of their land for ever, and also gave each member the use of his cottage and its garden and a holding varying from ½ acre to 2½ acres on which he could keep such animals as he and his family could look after. So popular were these holdings that by 1939 much of the peasants' time was spent on them and a large proportion of the livestock of the U.S.S.R. was their private property. So decrees went forth that they must put in a minimum of a hundred days per annum on the farm; this number has since been raised.

There is little doubt that when peace returns this modified system will be able to provide the U.S.S.R. with the food needed for a rising standard of life. The theoretical objection still remains: the peasants are not employees and do not come under the labour code: they have, for example, no trade union and are ineligible for old-age pensions. "Peasant-mindedness' still continues and they are not one class with the factory workers. But so many theoretical difficulties have been brushed aside in the U.S.S.R. for a realistic solution that we may expect this also will disappear and the system will become wholly acceptable.

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Humus

F. Yu. Geltser has strongly criticized the commonly-held view of humus (or humic acid) as a product of the decomposition of plant materials and of lignin in particular. He points out that the only similarities between humic acid and lignin are that both are soluble in alkali, forming coloured solutions. Humic acid is, however, sharply distinguished from all lignin-like substances and from products of plant decay by its ability to unite and form stable complexes with certain mineral colloids. This property of forming the organo-mineral complexes described by A. F. Tiulin and characteristic of all mineral soils is not possessed by any other known class of organic compound. Geltser postulates that humic acid is formed from the products of plant decay by a quite distinct process of synthesis performed by micro-organisms, and that it has no genetic relationship with any of the recognized plant constituents. L. Meyer has advanced the hypothesis that the formation of organo-mineral colloids takes place *in statu nascendi* by the union of humic acid in process of synthesis with micaceous or montmorillonitic colloids in process of formation from primary rock minerals.

Geltser asserts that there are two distinct types of humus, one occurring in considerable proportions in chernozems and cultivated soils, the other in podzols, peats and acid soils generally. He ascribes the formation of the former to the action of bacteria and of the latter to the action of fungi, thus bringing his theories into line with those of W. R. Williams. A distinction according to physical and electrochemical properties between humic acid from peat and fertile soil, respectively, is also made by Springer. A. I. Natkina found a considerable difference in the elementary composition of the two kinds of humic acids, and concluded that processes of oxidation and dehydration had reached a relatively more advanced stage in chernozem humic acid. I. D. Sedletsky and G. V. Shimakova, on the other hand pointed out that the similarity in behaviour on heating of humic acids from both peats and soils testified to their identical structure, the thermal investigations thus confirming the evidence of electronographic and X-ray analysis. W. S. Gillman found the humic acids from three contrasting soil-types similar in chemical and physical properties. The non-nitrogenous fraction of humic acid appeared to consist of a slightly modified lignin complex.

F. Scheffer fractionated chernozem humus into a readily decomposed "nutrient" humus and a "permanent" humus which has important physico-chemical effects on the soil. The ratio of the latter to the former in chernozems is about 3 to 1. The aim in making manure is said to be the conversion of as much lignin as possible into permanent humus, the process being aided by mixing the organic material with soil and lime.

C. Enders has put forward a theory that humic acid is formed by the condensation of amino-compounds with methyl-glyoxal produced from carbohydrates. Lignin is supposed to be formed in plant tissue in an analogous way—(*Soils and Fertilizers*, 1943, Vol. VI, No. 3, p. 109).

* * *

Technology of Tea

In an address on "The Technology of Tea" Dr. E. B. Hughes, past-president of the Society of Public Analysts and other Analytical Chemists, stated that tea-growing areas are not now confined to Asia; the necessary tropical or subtropical conditions exist elsewhere and tea is now grown

extensively in Africa, even so far south as Natal, and also in Russia. In the production of black tea, as distinct from green tea, the main processes are withering, rolling, fermentation and final drying. Withering is a partial natural drying process at as cool a temperature as possible. It dries the leaves to a condition in which they can be rolled and twisted by mechanical action simulating rotatory rubbing between the hands; this damages the cells, whereupon, possibly as a result of "disorganized respiration", oxidase of the leaf brings about "fermentation". This so called fermentation is mainly oxidation of polyphenols of the leaf to quinone compounds, which readily produce reddish, copper-coloured condensation products. The polyphenols of the leaf are the so-called tea tannins, but they are not tannins in the ordinary sense, as they are not able to convert hide into leather. The rate of "fermentation" is highly important; if too rapid, it gives inferior products, and the greater rate of fermentation, combined with lower quality of leaf grown in hot humid conditions, produces a commoner quality of tea. Indeed, the differences in quality and character between teas from different areas are due mainly to differences in geographical and climatic conditions, rather than to varietal differences in the plants grown. Changes in climatic conditions in the same area may produce much choicer tea at one time than a month earlier or later. It is the practice of blending, dependent on the remarkable skill of the tea taster, that enables the consumer to be supplied with brands of unchanging character. Most good teas, as supplied to the consumer, are blends of more than a dozen lots. Green tea is not subjected to "fermentation", the enzyme activity being destroyed by heating the leaf (steaming) as soon as possible after plucking, after which the leaf is rolled and "fired".—(*Nature*, Vol. 153, No. 3881, p. 339).

* * *

Beneficial Effect of Preliming upon Phosphate Uptake from Incorporation of Monocalcium Phosphate

W. H. MacIntire and B. W. Hatcher. *J. Am. Soc. Agron.* 34, 1010-16 (1942). Preliming of 35 soils caused an enhancement in phosphate uptake by rye seedlings from subsequent applications of monocalcium phosphate. The increases were accredited to two factors; (a) a considerable fraction of the water soluble acidic phosphate reacted with either the residues of the added carbonate or the resultant calcic silicates to form dicalcium phosphate and (b) the capacity of acidic soil to effect phosphate fixation was diminished substantially by the replacement of the hydrogen ion of the colloidal complexes by the calcium (*Chemical Abstracts*, Vol. 37, No. 4, p.993).

Organic Silicia in Cane Juice

Hugo P. Kortschak. In a large number of papers on cane juice clarification, mention is made of organic compounds of silica. The existence of such compounds was, apparently, first suggested by Muller in 1921. The reasons given by him for assuming the existence of such "complex organo-siliceous bodies of a colloid nature" are presented below, with comments by the present writer in italics. (1) "The silica of the juice . . . sometimes . . .forms soluble compounds with the lime." *Calcium silicate is quite soluble in sugar* solutions. (2) "In the *Graminae* . . . . . silica is not combined to the mineral bases of the plant (since hydrofluoric acid eliminates it completely) but posseses the faculty of being soluble in alkali at certain periods of the life of the plant." *Colloidal silica itself is quite soluble in alkalis.* (3) "In the case of juice obtained by diffusion, the major part of this silica is precipitable by lime" (i.e., the silica compound, being in colloidal form, is not extracted by diffusion). *Colloidal silica itself is not diffusible.* (4) "The colloidal compounds for the greater part are destroyed by super-heating." *This could be due to silica passing from the colloidal form into true solution, or by heat coagulation of the silica. The fact itself (better precipitation of silica after super-heating) has been questioned.* The only supporting evidence produced since the publication of Muller's article is the fact that some of the silica in cane juice cannot be determined by the molybdate method. However, this method is valid only for dissolved silica, and any solid or colloidal silica does not react. We may, therefore, conclude that there is no necessity for assuming the existence of an organic compound of silica in cane juice, since all the evidence submitted can be explained by the presence of calcium silicate or colloidal silica.—(The *Intern. Sugar Journal*, Vol. XIV, No. 529, p. 18).

ERRATA

(i) Article by Stephens S. G. Vol. 21, No. 2, (1944). In Table, page 25 column 2, line 1, for "Virgin Islands 1,026,699 lbs." read "Virgin Islands 289,077 lbs."

(ii) Article by A. F. Posnette on "Pollination of Cacao in Trinidad," Vol. XXI, No. 6, p. 118, under "References", Col. 2, line 7, for Strickland, E. H., read "Strickland, A. H."

THE subscription to *Tropical Agriculture* is six shillings per annum, post free, Trinidad currency, to all countries within the British Empire or seven shillings and sixpence, post free, Trinidad currency, to all other countries. Subscriptions can commence at any time during the year.